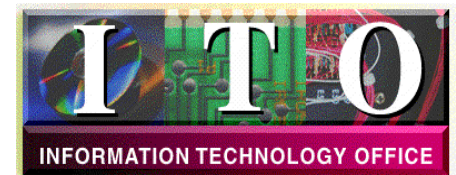




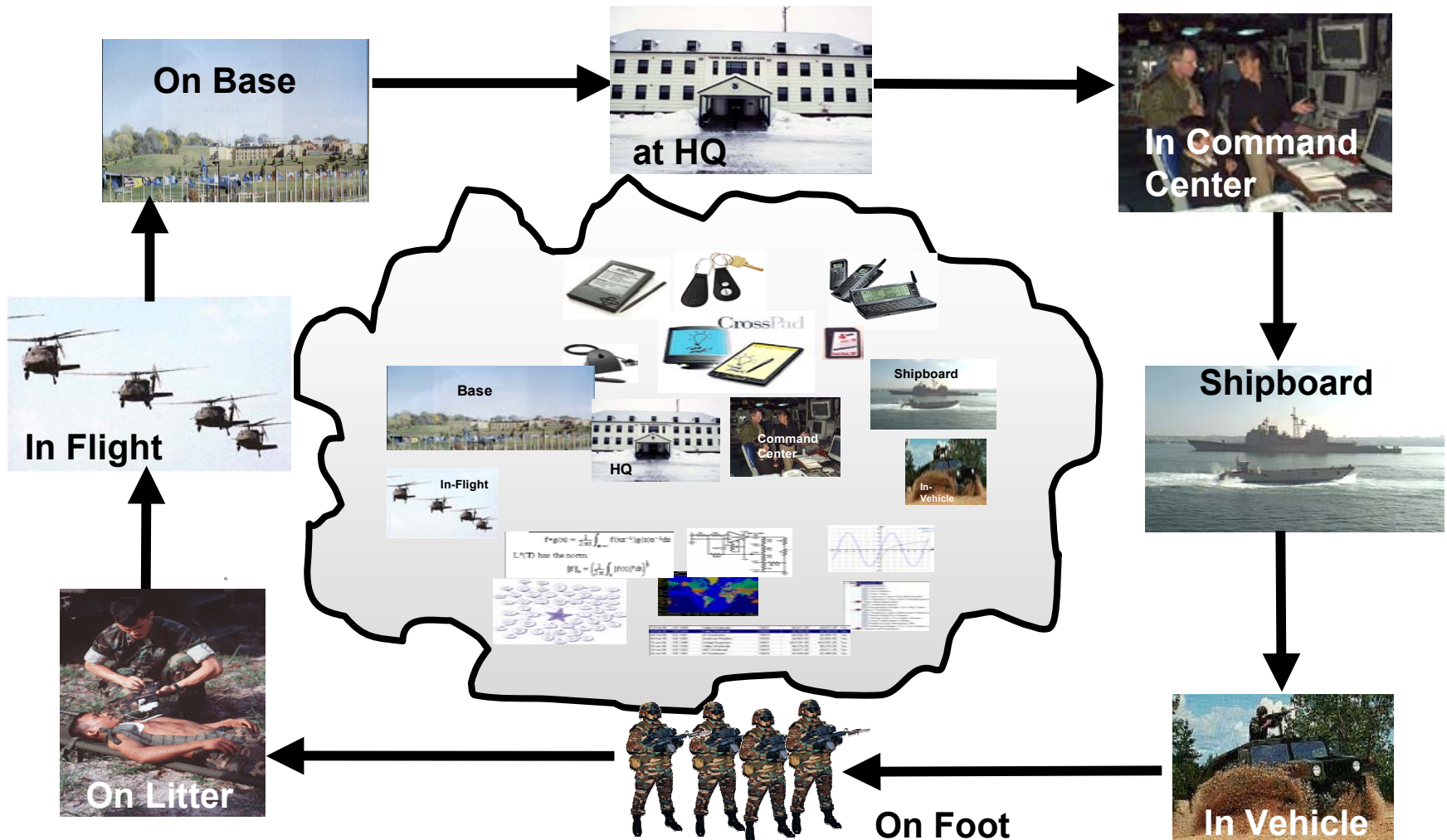
Smart Spaces to Go

Dr. Kevin Mills

Dr. Jean Scholtz



Human-Information Interaction that transcends the desktop



People work and live on the move



Rescue Workers



Doctors



Soldiers



Police Officers



Factory Workers



Sailors

How do people on the go interact with information today?



Growing population of portable, embedded, wearable computing devices, each specialized for particular tasks, but

- **User interacts with each device independently**
- **Applications control, format, and present specific information**
- **User must track, convert, and transfer information across devices**

Two Things Have Changed

1. Networking-capable PDAs, Sensors, and Devices

IrDA and Blue Tooth Wireless LANs and Fire Wire and USB Plug-and-Play Buses

2. Location-aware Devices

GPS, Cell Phones, Active Badges





Smart Spaces to Go

**Toughest
Issues?**

Three Hard Problems

**Coordinating interactions across devices
and modalities**

**Enabling software to manage information
mobility**

**Adapting information delivery
using knowledge of people, places, and devices**



Smart Spaces to Go

Coordinating Interactions

Our
Approach?

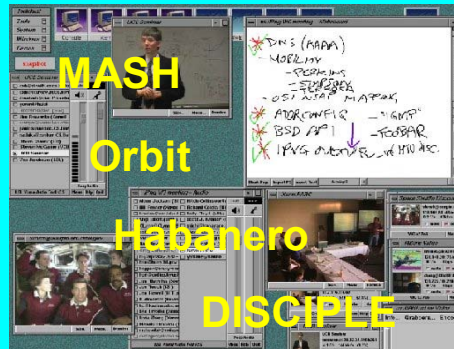
New Idea: Poly-Device, Poly-Modal Interface

Develop a distributed coordination bus that:

- enables coordinated user interactions, individually or collaboratively, across multiple physical devices and multiple modalities
- dynamically composes interfaces optimized for tasks, modalities, and devices



Multi-modal interaction and tracking exists in ITO research prototypes



Multi-party, distributed event buses developed by ITO



Multi-media, cross-device drag-and-drop developed by ITO



Managing Information Mobility

New Idea: Active Information

Develop systems of mobile, replicable objects that communicate as groups to:

- track location, state, and trajectory of information users, replicas, and linked objects
- plan information movement and replication
- implement consistency, access, and sharing policies among objects and replicas

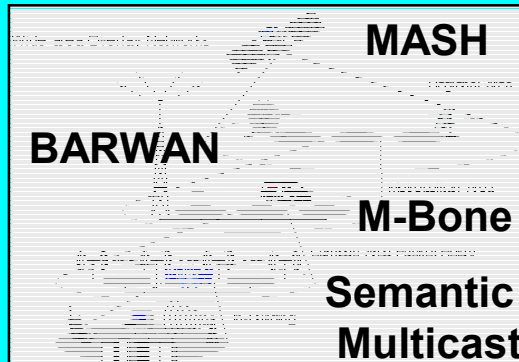
CORBA
Microsoft
COM



JAVA
POWERED



Python



Commercial push toward distributed objects and mobile code

New multicast, transcoding, and beaconing protocols emerging from ITO research

Processing-capable network infrastructures under development in ITO programs



Smart Spaces to Go

Adapting Information Delivery

Our
Approach?

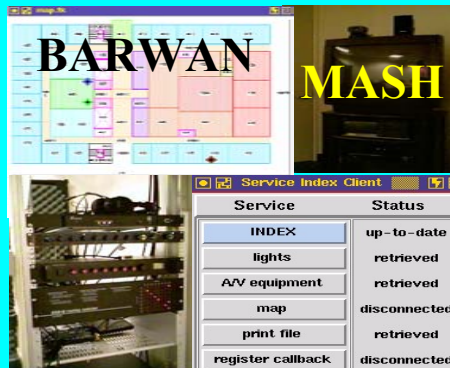
New Idea: Inter-Space

Couple sensor data with resource and scene description languages to model physical and logical space, as perceived by people, so that software can:

- exploit location, proximity, visibility of resources to determine delivery devices
- adapt presentation to characteristics of available devices and services



Small, capable sensors
commercially available



Location-based networking
services emerging from
ITO research

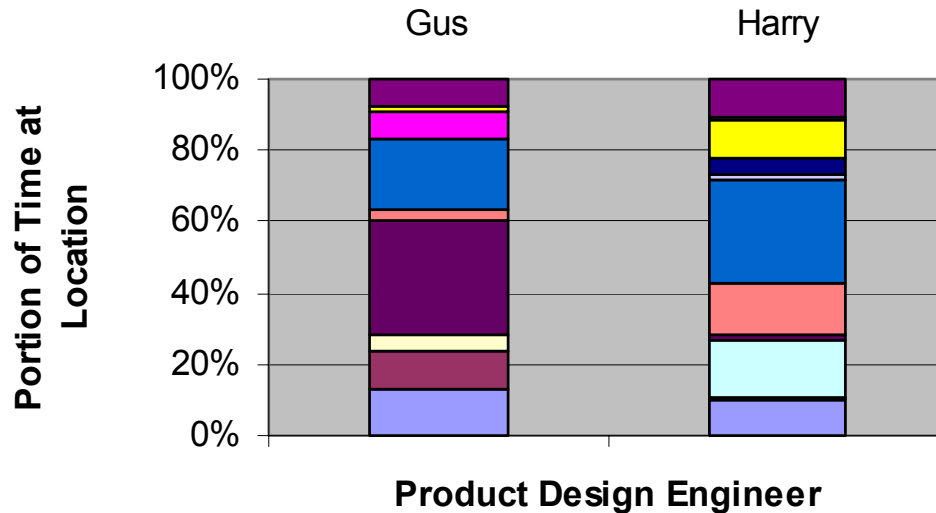


Vision-based computational
geometry research funded by
DARPA



Increase Information Access

Mobility Over Four Working Hours



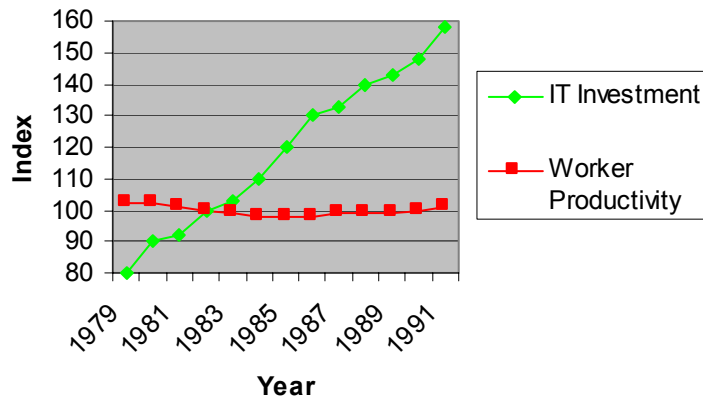
Source: Bellotti and Bly study of distributed collaboration in a product design team, Proceedings CSCW 96.

- 10-13% of work completed at desktop
- 76-82% of work spread between 11 other locations
- 8-11% of time spent moving between locations



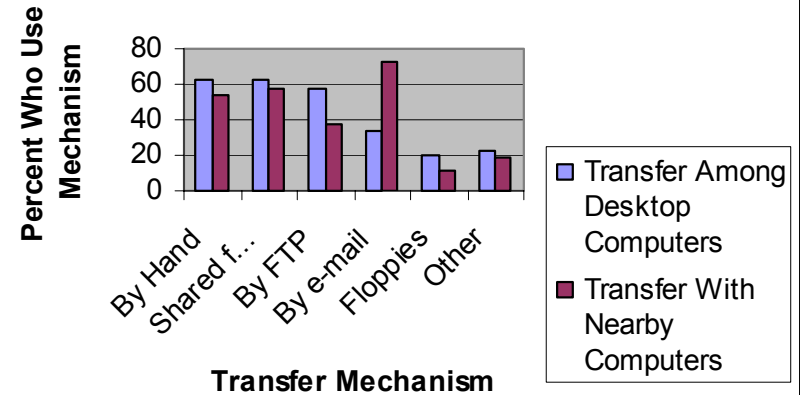
Increase Task Productivity

Worker Productivity vs. Information Technology Investment in the Service Sector



Save Work/
Make Work?

How Do Software Engineers Transfer Information Among Computers?



- Service sector IT investment rises 8% yearly
- Service sector productivity remains flat

- Computers on desktop: 54% ≥ 3 ; 39% = 2; 7.7% = 1
- Transfer data between desktop computers: 70% very often and 25% often
- Transfer data between nearby computers: 28% very often; 23% often; 36% sometimes

Source: Thomas K. Landauer, The Trouble with Computers, 1996, citing data from Roach, 1992

Source: Jun Rekimoto, study of software engineers Proceedings of the ACM Symposium on User Interface Software Technology (UIST), 1997

Human-Information Interaction that transcends the desktop

Well-Worn HCI Model

Windows, Icons, Menus , Pointing

User Manages Personal Information

User Initiates All Interactions

Application Software Formats Data

New Smart Spaces HII Paradigm

Multi-device, Multi-modality Interaction

Critical Information Follows User

Information Anticipates User Needs

Information Adjusts to Task/Environment





Smart Spaces to Go

When Can
We Start?



Going Our Way?